PAVEMENT EDGE LIGHT SAFETY SYSTEM, PELSS:
VISUAL ENHANCEMENT TO AIRFIELD LIGHTING

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Traditional Taxiway Lighting

- Single point of illumination, 60 years +
- Individual nodes of light can cause confusion
- May appear as a “sea” of random blue lights
- Inadequate visual cues

Pavement Edge Light Safety System

- Improved boundary recognition
  - Illuminated horizontal linear bar
- Provides information related to BOTH
  - Location of the pavement edge
  - Orientation of the taxiway edge

Related Research

- LED Linear Source project – FAA Technical Center [1]
  - Decade of stratified research related to LED's
  - Seeks to determine extent of improvement
  - Specification Development - minimum length and spacing

Concerns

- On-going concerns
  - Baseline evaluation of FAA Study
    - Assumes 2 ft. bar is same as a single node from a distance
    - Single node data not presented
  - Lighting in the immediate vicinity is also relevant
    - Response time measured from 2000 feet in FAA study
    - Quantitative data has been positive
    - Qualitative data not obtained through scientific measurement

Runway Incursion Prevention

- 2012, this issue topped the NTSB "Most Wanted" list
  - Situational Awareness/Runway Incursions

- Improved situational awareness
  - IMPROVE recognition of intersections and edges
  - REDUCE incidents, accidents, incursions, and excursions

Traditional Lighting

- Point Source Lighting Poorly Outlines Sections of Taxiway
- Additional Lamps Needed at Curves and Intersections to Define Edges
- Visual Interpretation can be Challenging
  - Worsens with deterioration of weather

PELSS Lighting Enhancement

- Linear light bars enhance visual feedback
  - Overall situational awareness is improved
  - Fewer lamps are necessary to define edges
  - Less lighting clutter

PELSS Lighting Enhancement

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  -
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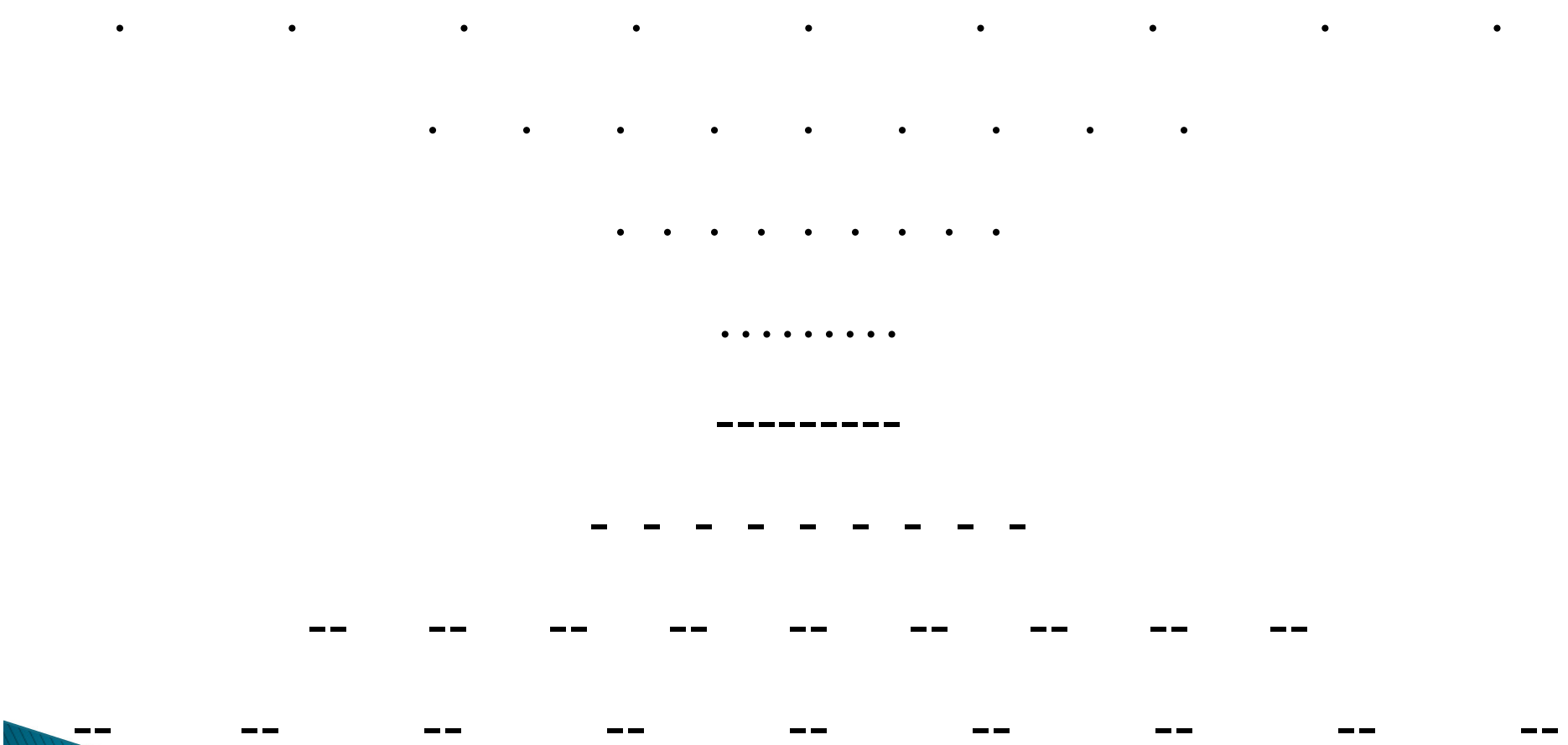
  -

Taxiway – Present State, Night

Taxiway – Linear Rendering, Night

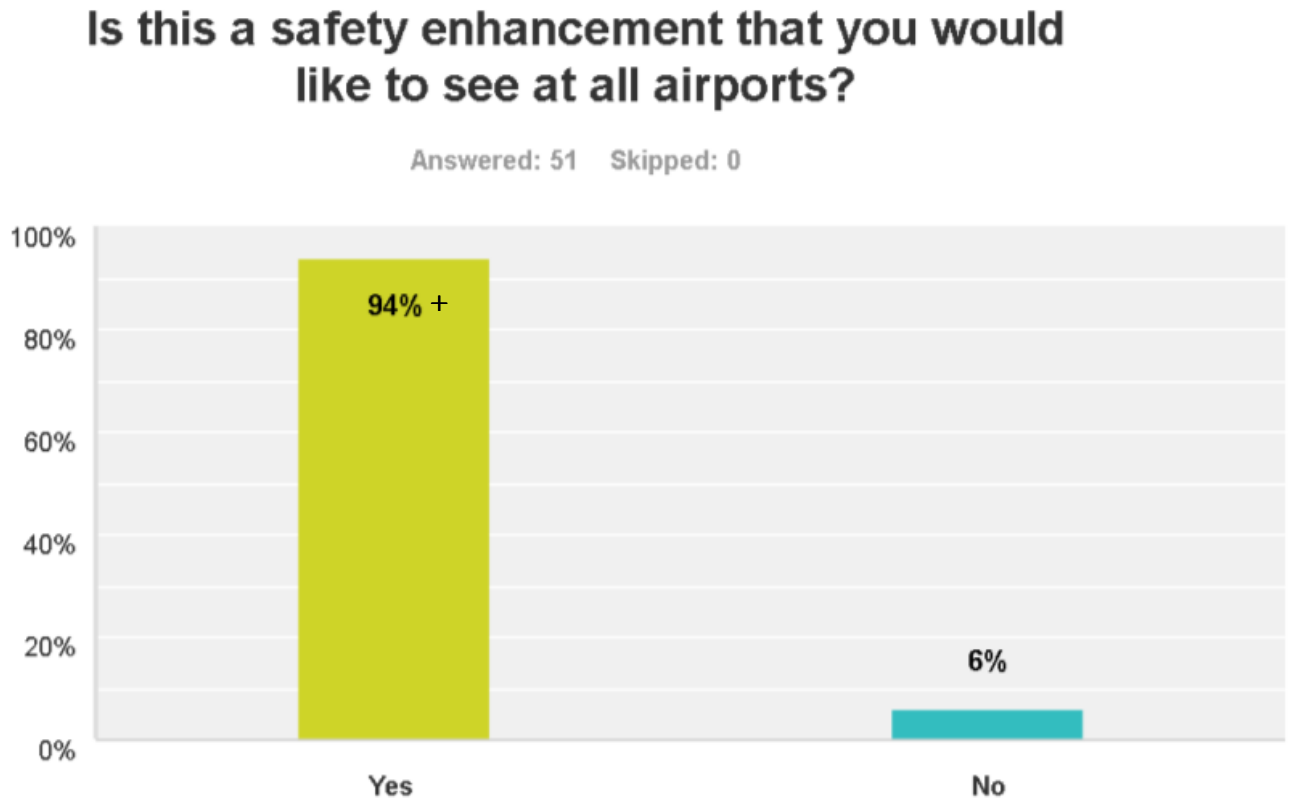
PELSS Enhancement, Night

Pixelated Foundation



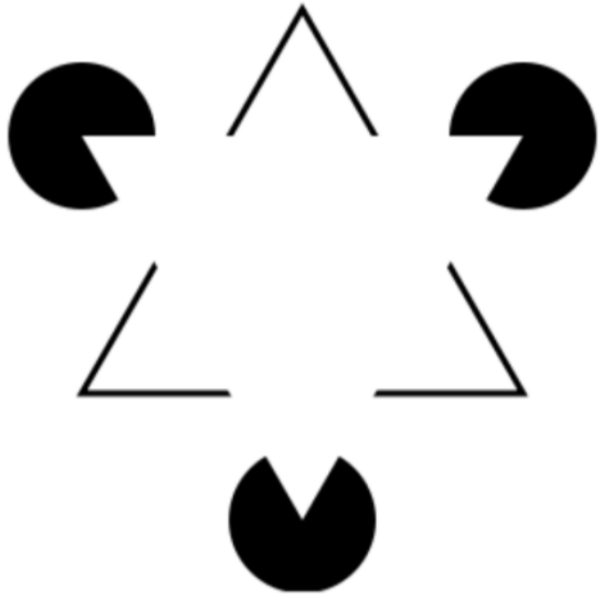
Industry Feedback

- 2013/2014, Cleveland Hopkins International Airport
- 25 light-bars fitted to taxiway lights along apron edge



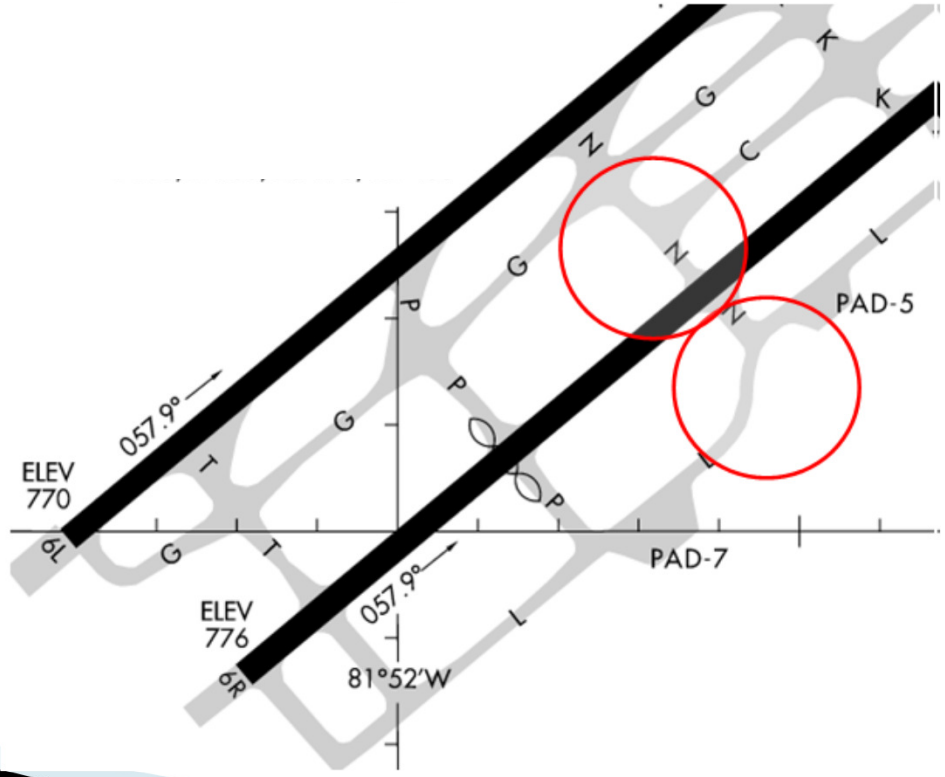
Illusory Boundaries

- Recreation of actual boundary in the mind
- Gestalt Psychology principles [3]
  - Mind forms a global whole with self-organizing tendencies
    - Symmetry
    - Similarity
    - Proximity



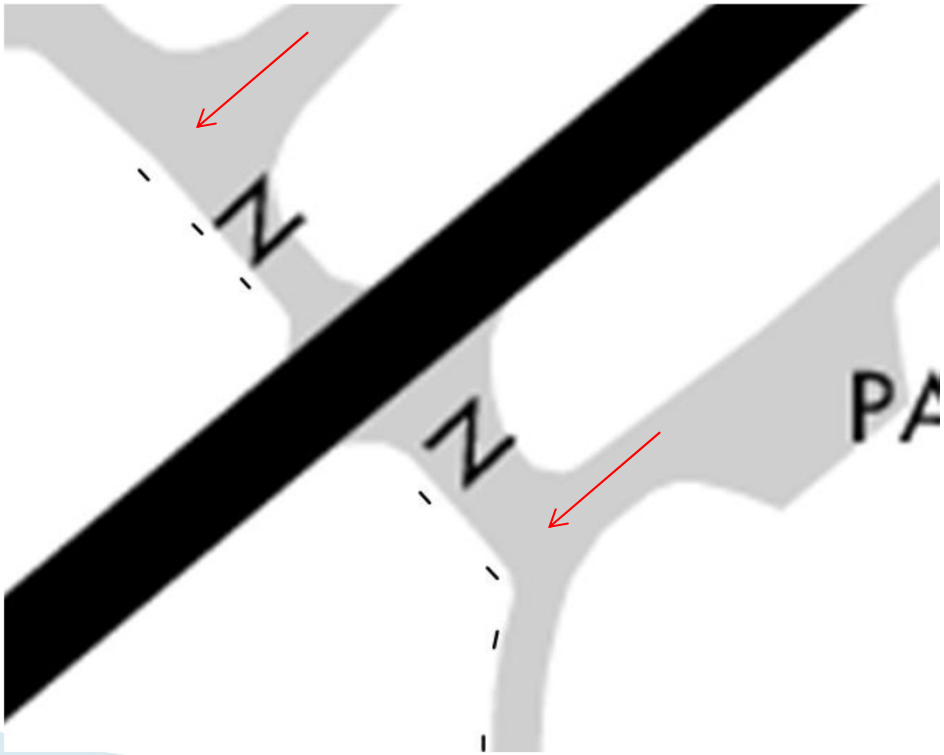
Case Example

- Problematic taxiway geometry
  - Expectation - Parallel runways have parallel taxiways



Case Example

- A linear marking will prevent an excursion

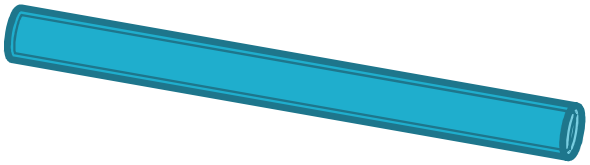


Illusory Boundaries

- Traditional boundary
  - Nodes of light create illusory boundary
  - Close spacing used to enhance visual aid
- Recent taxiway geometry guidance from the FAA
  - Will improve boundary recognition
    - Symmetry
    - Similarity

Perspective

- ~Perpendicular viewing Angle



- Oblique viewing angle

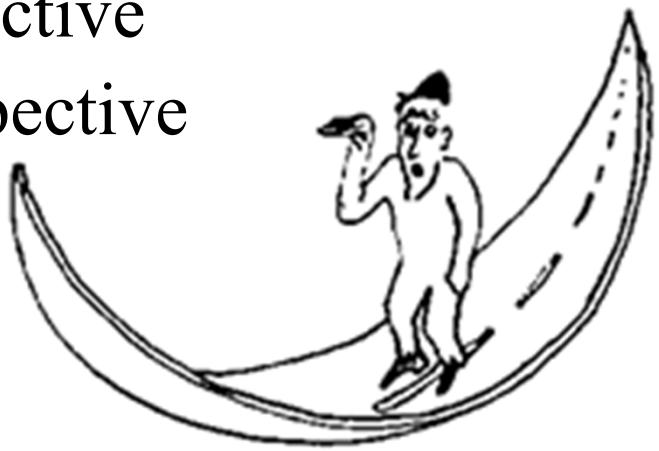
- Obtuse viewing angle

<u>Linear segments shown are the same length</u>

Distant segments viewed from an obtuse angle will appear as a single node, regardless of length

Dimension and Perspective

- Degraded visual recognition
  - Lack of foreground and background references
  - Viewing angle
- Improved linear segment visibility
  - Elevated viewing perspective
  - Off center viewing perspective



Form Perception

- Involves a number of psychological mechanisms that function in a complementary manner [5]
  - Curve marker
  - Vertices marker
  - Mid section marker

Form Perception

- Human Image Understanding

Form Perception

- Human Image Understanding

Form Perception

- Human Image Understanding

Form Perception

- "Biederman's Cup"[6]
- Perception of Degraded objects
  - Deletions of
    - Contour/Midsection
    - Vertex

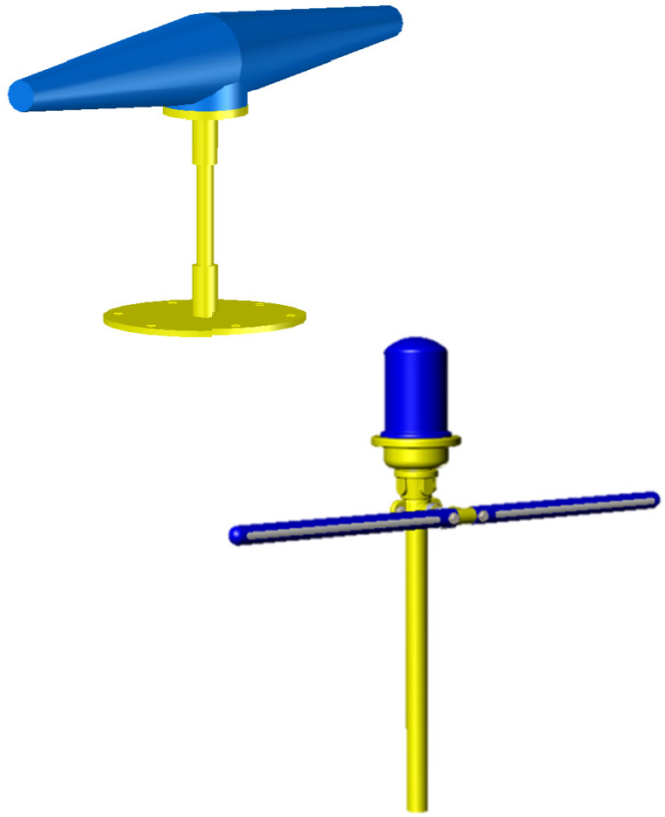
Scale versus Shape

- Visual information is a function of "shape only"[7]
- Size is a factor only for the eye to detect shape
- Distant objects
  - So small that the eye cannot perceive shape
  - Appear as if they occupy single points

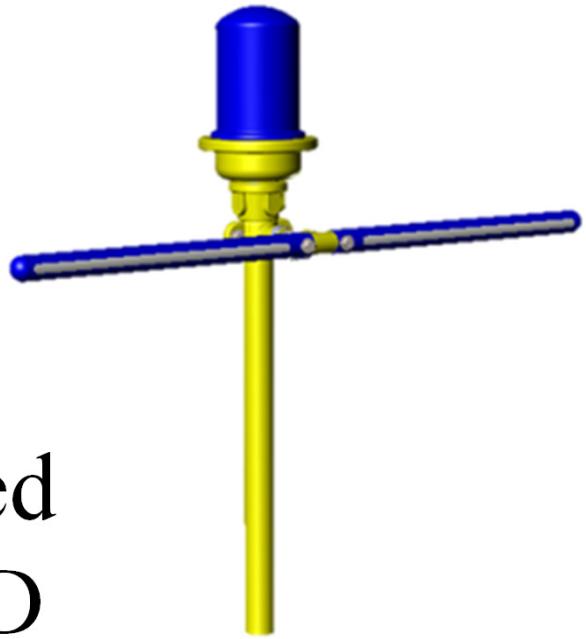
(A distant linear segment shape is typically discernable for *one minute*, while travelling toward it at 20 knots, before reaching the pavement edge)

Design Evolution

- Logistics
  - Ease of installation
  - Ground maintenance
  - Environment
- Form
  - Low profile
  - Weight distribution
- Function
  - Visibility
  - Alignment
  - Spacing



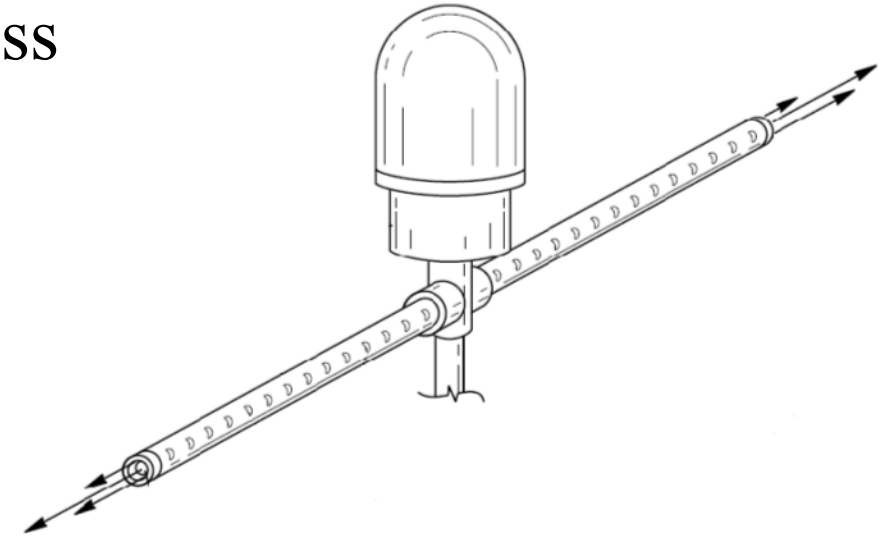
Design Evolution



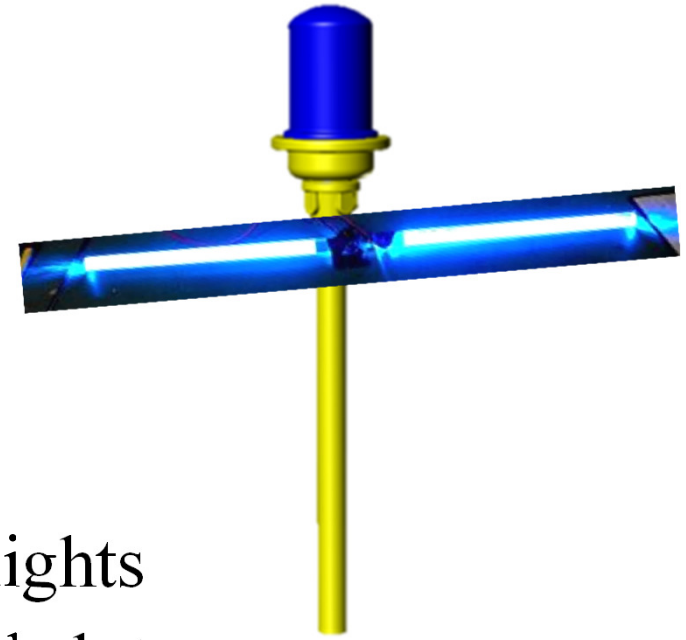
- Previous/test version depicted
- Incandescent updated to LED
  - Retrofit of existing taxiway lights
  - Slots allow light to emanate directionally
  - Hollow plastic tubes diffuse light
  - 13 blue LED's in each arm

Design Evolution

- Light Beam – Low Visibility
  - Focused beam emitted from tube end
  - Illuminates Fog and Snow
  - Extends the visible beam beyond the physical bar
  - Enhances pilot awareness



Design Evolution



- Translucent tube
  - Retrofit of existing taxiway lights
  - Metallic tubes with elongated slots
    - light emanates directionally
  - Two translucent plastic tubes fitted within
  - 2 high intensity blue LED's in each arm

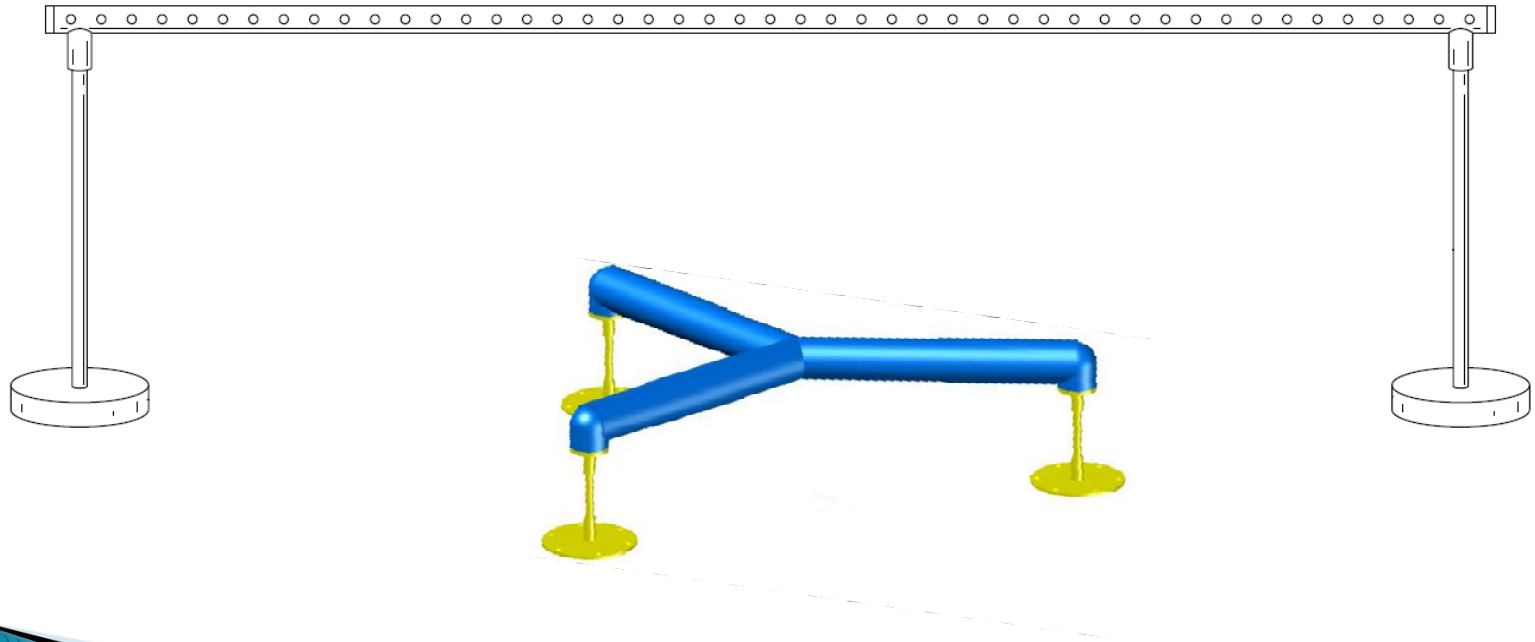
Economics

- LED Retrofit
  - Previous design - 26 LED lights in two foot length
  - Next generation - Translucent tube
    - 4 LED lights in two foot length
    - 1.4 amp / 12 V

- Complete Fixture
  - Without traditional bulb
  - Equivalent to current fixture cost

Extended Lengths

- If the FAA specification requires linear sources of greater length, multiple posts may be utilized



Next Steps

- FAA Advisory Circular to include an option for linear light sources
  - May specify length, intensity and spacing
  - Progress on hold until AC is revised

Luminaerospace, LLC

- An intellectual property holding company
  - Founded in 2010
  - More than a dozen members (investors)
- Mission Statement
  - Pursue FAA approval of practical elevated linear lighting specifications
  - License this technology to existing airport lighting manufacturers
- United States Patent with priority back to 2009
- Additional protection pending
  - Europe
  - Asia
  - Americas

Discussion

References

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- 6. Biederman, I, *Recognition-by-Components, A Theory of Human Image Understanding,* Psychological Review (1987), Vol. 94, No. 2, 135
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